Overview of Offshore Well Completions

OOC briefing to EPA Region 6

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Overview

- Introduction to US Gulf of Mexico
- Offshore Well Completion Techniques
  - Why, How & What
- Environmental Regulations Overview
- Operational Considerations
- Summary

Offshore Well Completions: Key Points

- Primary driver of offshore completion design is sand control with an extensive history of successful application in the GoM
- Offshore completion activities are covered extensively by existing regulations – both operational & environmental
- High volume hydraulic fracturing of unconventional formations is not occurring offshore GoM
- Concerns for implications to drinking water aquifers is not pertinent to offshore operations
- Remoteness of operations ensures minimal, if any, public impacts from completion activities

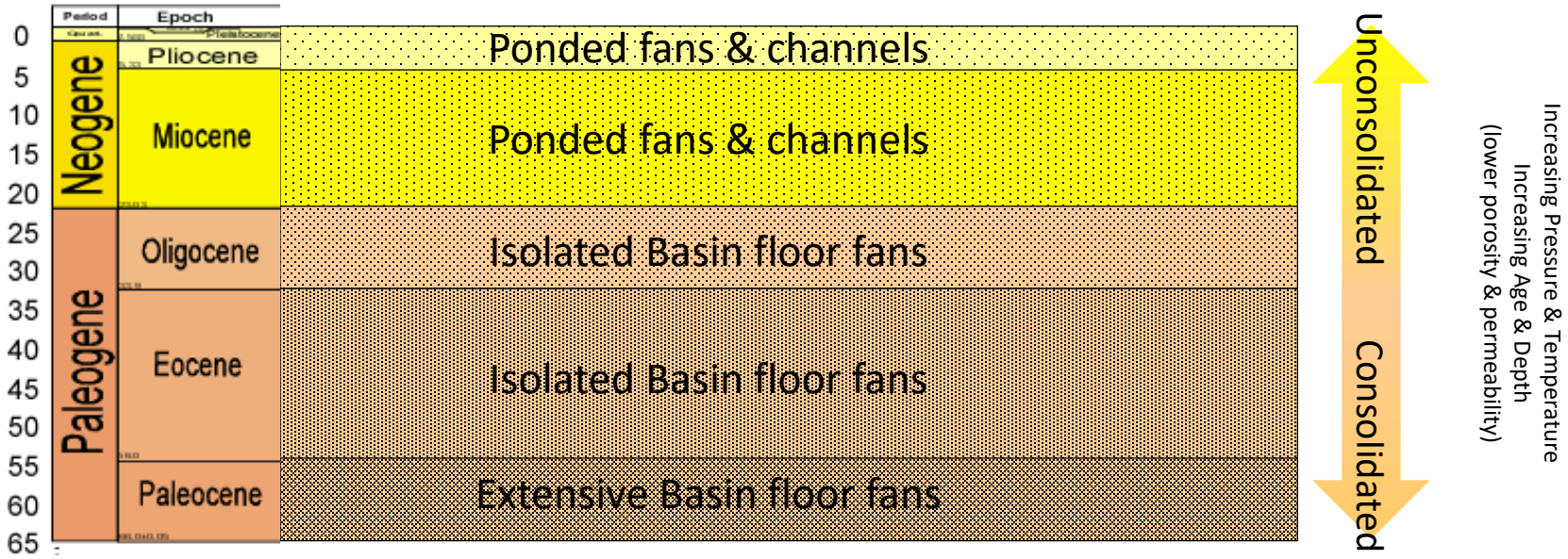
US Gulf of Mexico OCS Overview

- Significant source of US Energy Production
  - OCS Annual Production Impact (FY 2014 data)
    - ~ 685 MMBOE (459MM Barrels Oil & 1.33 TCF Natural Gas)
- Significant Revenue Stream to US Government
  - OCS production generates 2nd largest source of income to US treasury behind revenues collected by IRS
    - $7.1B in Royalties/Rents (FY 2014 data)
- Economic Engine (ONRR 2013 Economic Report, BSEE SEMP data)
  - Jobs – 705,000 – 0.5% US employment (~ 57,000 offshore)
  - Value – over $62B value added output – 0.4% GDP
- Highly Regulated Industry
  - Federal Agencies with oversight authority include:
    - BSEE, BOEM, USCG, ONRR, EPA, F&WS, NMFS, DHS, NOAA & others

Offshore Well Completions: Basics

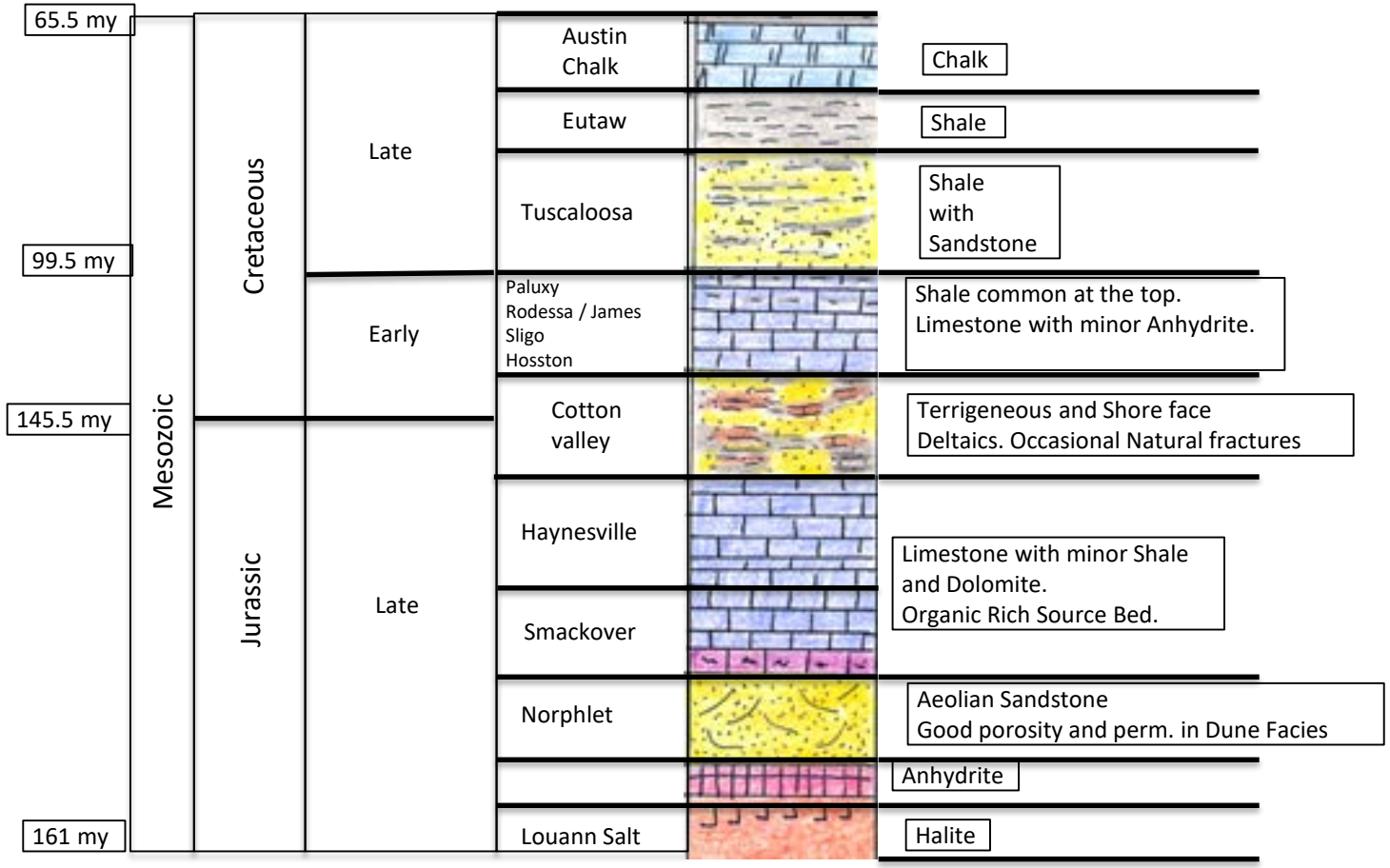
- Reservoir characteristics drive the well completion requirements:
  - Unconsolidated sands
    - high permeability reservoirs
    - formation damage (skin) bypass
    - sand control – gravel pack / frac pack
  - Consolidated sands
    - low permeability reservoirs
    - inducing relatively near well bore fracture for stimulation

Offshore GoM Deepwater Sand Types

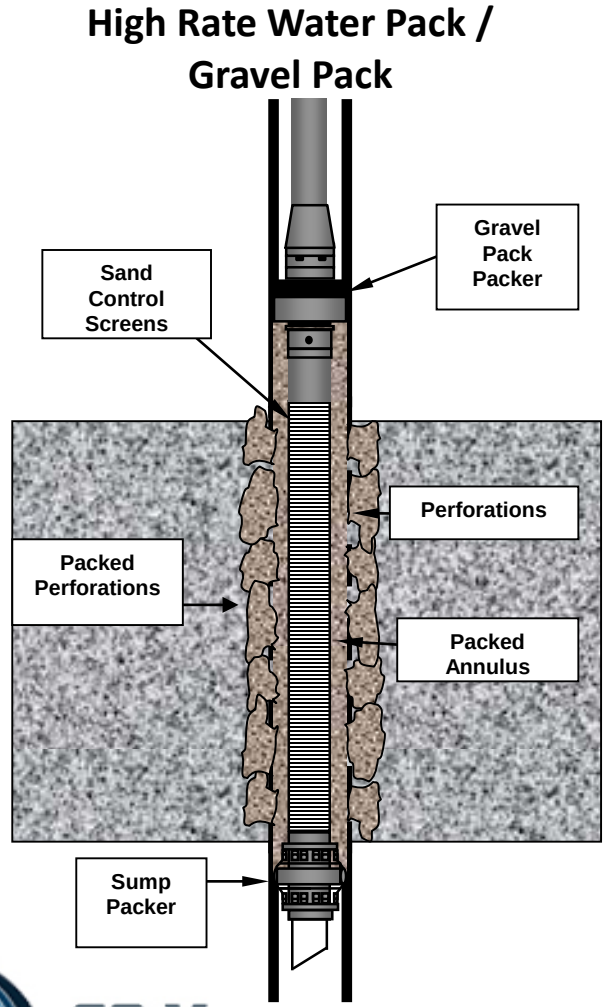


- **Neogene (Miocene / Pliocene):**
  - Permeability and porosity is maintained at shallow depth
- **Paleogene (Oligocene / Eocene / Paleocene):**
  - Permeability and porosity are challenged at depth with increased pressure & temperature
  - Includes Lower Tertiary

Offshore E. GOM Central Planning Area
Cretaceous and Jurassic Lithology



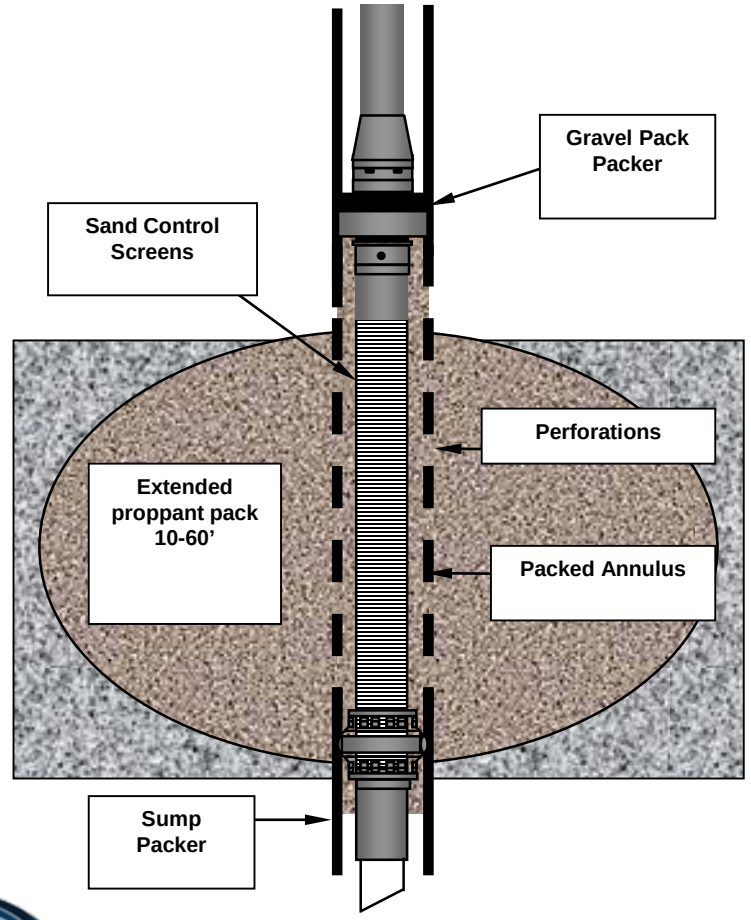
Offshore Completion Techniques: Unconsolidated Sands – Historical



- traditional sand control
- long standing practices – 50+ years
- historically, represented ~100% of GoM sand control completions
- currently, < 5% because technology has evolved
- water, brine or gelled brine as a carrier fluid
- only treats annulus and / or near-wellbore area and packs the annulus for sand control
- significantly reduces amount of sand that flows into well bore
- limits plugging and reduces frequency of maintenance operations on well bore
- covered by existing regulations / permits

Offshore Completion Techniques: Unconsolidated Sands – Current

Frac Pack / Gravel Pack



- long standing practice – 25+ years
- currently, >75% of GoM treatments
- gelled water or brine as carrier fluid
- induces fracture to create tighter proppant pack but is not designed for significant stimulation like hydraulic fracturing
- 10 - 60 ft. fracture half-lengths
- typically 54-216 bbls proppant volume
- bypasses near-wellbore damage; extends sand proppant pack further distance from wellbore
- packs the annulus in a tighter manner than traditional gravel pack
- allows for higher reliability
- reduces well-intervention / sidetracks as compared to conventional sand control
- covered by existing regulations / permits

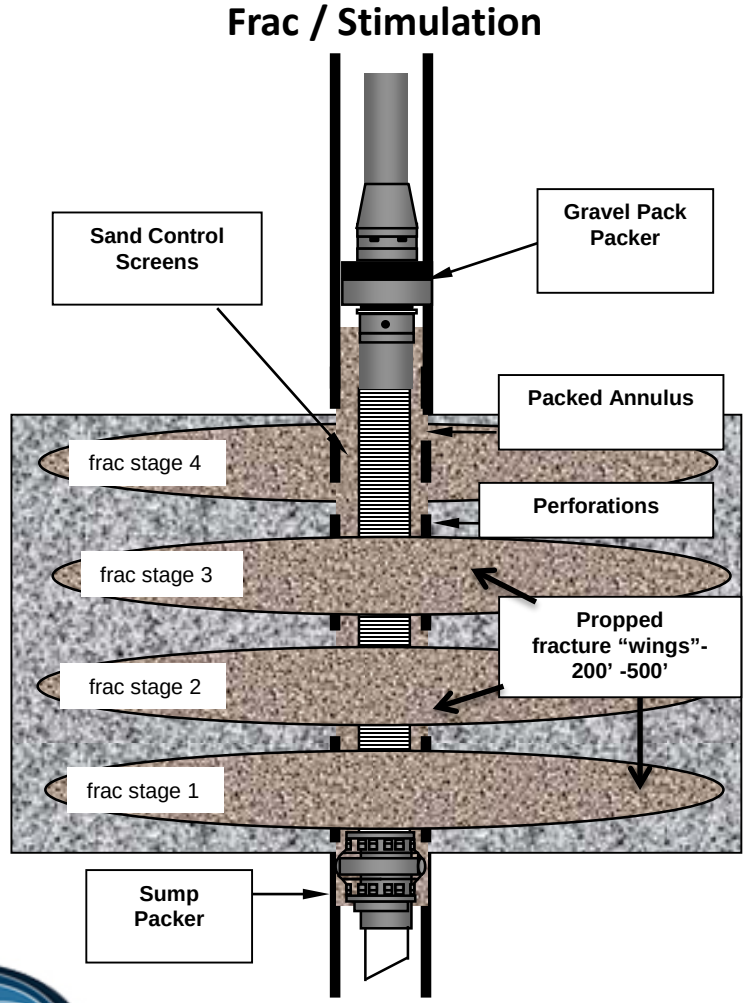
Offshore Completion Techniques: Consolidated Sands – Why?

- In general, these formations are hydraulically fractured to:
  - improve production rates
  - recover the investment faster
  - stimulate the reservoir
  - recover reserves not otherwise commercially viable
- Additionally, in offshore fields, these formations are hydraulically fractured to:
  - reduce the total number of wells required to efficiently drain a given reservoir
    - this results in fewer wells drilled and less environmental impacts associated with field development

Offshore Completion Techniques: Consolidated Sands – How?

- Pumping a fluid into a consolidated permeable formation at an injection rate high enough to fracture that formation
  - higher fluid viscosity improves fracturing capability
  - higher injection rate improves fracturing capability
  - primarily designed to stimulate the reservoir
- Fracture size
  - reservoir properties contain the orientation of the fractures
  - highly controlled
  - fracture distance from wellbore is limited

Offshore Completion Techniques: Consolidated Sands – Current



- technique has been practiced onshore for decades
- utilized offshore for ~10 years
- currently, < 5% of GoM treatments
- 200 – 500 ft. fracture half-lengths
- typically 216-540 bbls proppant volume / frac stage (2-5 frac stages/well)
- reservoir characteristics-driven (requirement for reservoir stimulation)
- minimizes the number of wellbores required to develop the resource
- allows development of natural resources previously not commercially viable
- discharge footprint same order of magnitude as frac pack
- covered by existing regulations / permits

Sand Control Completion Operations: General Step-by-Step

- First, gel and water are blended together
  - Typically use quality guar, starch or cellulose gel
    - many gel powders are found in commercial foods (ice cream, gravy, ketchup, etc.)
    - this mixture is referred to as frac gel and is thick like vegetable oil
- Second, proppants are blended into the gel in a large blender that mixes the ingredients
  - Additives include cross-linkers, surfactants and buffers
- Finally, the resulting mixture becomes a cross-linked fluid that behaves like *Jello* ®

Sand Control Completion Operations: General Step-by-Step (cont'd)

- Mixture is pumped downhole, where the gelatin-like fluid transports proppant into the created fracture
- Fracture becomes filled with proppant, and pumping is ceased
- Additives in the fluid system break the cross-link, turning the *Jello* ® like fluid back into a liquid
- Fracture closes on proppant trapping it in place, and fluid flows out of well during production

Sand Control Completions Operations: General Step-by-Step (cont'd)

- Proppant provides a highly conductive channel to allow reservoir fluids to move easily toward the wellbore, enhancing well productivity
- Routinely utilize **mini-fracs** to gain information about reservoir to help design main treatment
  - Mini-fracs are followed by mini-frac flush fluid to prepare well for main treatment

Well Treatment Volumes

	Offshore Conventional		Onshore Unconventional	
Type	**Typical Volume (bbls) Unconsolidated (conv sand control & frac pack)**	**Typical Volume (bbls) Consolidated (hydraulic fracturing)**	**Typical Volume (bbls)**	**Offshore Fluid Description**
Other fluids assoc. with Well Completion (non-frac)	1,500-7,000	1,500-7,000	1,500-7,000	From seawater to high density salt solutions (i.e. brines) plus treatment additives
Mini Frac	500-700	500-700	Not Applicable	High density salt solutions plus treatment additives
Mini Frac Flush	500-800	500-800	Not Applicable	High density salt solutions plus treatment additives
Main Treatment	1,500-2,500	5,000-7,000	30,000-50,000 approx.	High density salt solutions plus treatment additives, including proppant
Main Treatment Flush	500-800	500-800	200-500	High density salt solutions plus treatment additives

Note: Typical volumes denote representative volumes used in each respective environment

Well Completion Techniques

Technologies used ***Onshore***

- Primary driver
  - formation stimulation
  - create fractures in tight rock
- Unconsolidated sands
  - gravel pack
  - frac pack
  - acid stimulation
- Consolidated sands
  - frac / acid stimulation
- Shale (unconventional resources)
  - high volume hydraulic fracture

Technologies used ***Offshore***

- Primary driver
  - formation stimulation
  - sand control
- Unconsolidated sands
  - gravel pack
  - frac pack
  - acid stimulation
- Consolidated sands
  - acid stimulation
  - conventional hydraulic frac

Environmental Regulations: Completion Operations Overview

Offshore well completion operations for consolidated and unconsolidated sands are governed by existing regulations and / or permits:

- Air Emissions – regulated by BOEM through Air Quality Reviews or EPA via PSD / Title V regulations
- Water Discharges – regulated by EPA through NPDES permits
- Wastes – regulated by EPA, DOT, and states

Air Emissions

- How Regulated?
  - West of 87.5° longitude - Emissions are reviewed through BOEM Air Quality Review (AQR) process
  - East of 87.5° longitude – Emissions are reviewed through the EPA PSD and Title V permitting process
- Emissions covered include:
  - Engines (permanent and temporary)
  - Support vessels (when within 25 nm of platform or MODU, including stimulation vessels)
  - Flares
  - Etc.
- Emissions from well completion activities would be addressed

Water Discharges

- How Regulated?
  - EPA NPDES Permits
- In GoM, EPA has authority for permitting discharges to water under the NPDES program:
  - EPA Regions 4 (Eastern GoM) and 6 (Central & Western GoM)
  - Each region has issued a NPDES General permit for their area of the GoM (# GEG460000 and GMG290000, respectively)
  - Permits, in place since the 1990s, are renewed every five years to incorporate changes to requirements, initiate joint industry studies and the like
  - Permits contain specific testing requirements & limits for discharges associated with well completion / treatment / workover (CTW) operations

Waste Disposal

- How Regulated?
  - EPA RCRA and Solid Waste regulations
  - DOT / State waste transportation regulations
  - State waste testing & disposal regulations
- If well completion fluids do not meet NPDES discharge criteria, they are shipped to shore for disposal or recycle / reuse under the above regulations.

Other Considerations

- Water Resources
  - No drinking water aquifers impacted by offshore wellbores on the OCS
  - Offshore operations comply with zonal isolation standards for water and hydrocarbon bearing formations
  - Primarily use seawater, though onshore Gulf states' municipal water supplies are used to supplement
- Community Health, Noise, Traffic, Light
  - No nearby populations
- Worker Health
  - Offshore operations comply with OSHA, USCG, BSEE, etc.
- Induced Seismicity
  - No known instances observed in offshore operations

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Questions?